International Journal of Environment, Agriculture and Biotechnology
Vol-7, Issue-6; Nov-Dec, 2022

Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Peer Reviewed

Impact of Fecal Waste Management on the Profitability of Poultry Farmers in Nigeria

Eric Okomado[1], Christopher Osamudiamen Emokaro[2], Peace Chukwuyem Ugbekile[3]

[1]Department of Agricultural Economics and Extension Services, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria.
[2] Department of Agricultural Economics and Extension Services, Faculty of Agriculture, University of Benin, Benin City, Edo State, Nigeria.
[3] Department of Agricultural Economics and Farm Management, College of Agricultural Management and Rural Development, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Received: 11 Nov 2022; Received in revised form: 02 Dec 2022; Accepted: 06 Dec 2022; Available online: 11 Dec 2022

***Abstract*— *The observation that there is far more quantity of poultry waste than can be managed by land disposal being produced yearly suggests the obvious problem of poultry waste management. This scenario offers great opportunities for organic farming and bio-energy generation in Nigeria. Hence, this study examined the economic contribution of fecal waste to the profitability of poultry farmers in Delta State, Nigeria. A multi-stage sampling process was used to select the 123 poultry farmers for this study. The data collected were analyzed using descriptive statistics, profitability ratios and the Stochastic Frontier Profit Function model. The Gross Margin analysis gave a value of ₦5,771,437.10 and a Net Farm Income of ₦1,960.18 per bird. The profitability ratios showed a Profitability Index of 0.86, a Rate of Return on Investment of about 19.25%, and a Return per Naira Invested (RNI) of ₦0.23. From the Stochastic Frontier Profit Function analysis, veterinary cost and cost of labor for fecal waste management had a significant positive effect on profit efficiency. The cost of birds and depreciation on fixed input had a significant negative effect on profit efficiency. Age and cooperative membership of layer farmers were significant socioeconomic factors positively influencing profit inefficiency. While education and household size were shown to negatively influence profit inefficiency. It was therefore concluded that farmers should focus on improved quality feed either self-compounded or purchased and better emolument for their workers as these positively influenced their profit. They should also be enlightened on the huge benefit of fecal wastes-to-biogas-electricity technology.*

***Keywords*— Delta State, Gross Margin, Profit Efficiency, Profitability Index, Stochastic Frontier Analysis.**

I. INTRODUCTION

1.1 Background of the Study

Poultry production is one of the most developed aspects of the Nigerian livestock industry (Miebi, 2020), and with the increase in population, there is pressure on local poultry farmers and the potential to expand the sector (The Commonwealth Scientific and Industrial Research Organisation, CSIRO, 2021). This expansion is not unrelated to the fact that they have a high level of energy and protein as they are good converters of feed into usable protein (Farrell, 2013; Qaid and Al-Garadi, 2021) and some researchers have associated this expansion potential with various factors including relatively low production cost per unit, short incubation period, high returns on investment and the absence of geographical, cultural, and religious restrictions (Achoja, 2013; Akanni and Benson 2014; Heise *et al*., 2015). This implies that fecal waste generated from the industry contributes significantly to the total waste generated in agriculture.

While there is difficulty in getting the true figures of waste produced from the Nigerian livestock industry, there are obvious indications that the volume is massive, and the environmental consequences are enormous. In the wake of the 20th Century, Itodo *et al*., (2001) estimated 1.4 million, 6.40 million and 5.2 million kilograms of cattle, poultry, and piggery manure per day respectively. Another estimate shows that about 932.5 tonnes of manure are produced annually from the well-established poultry industries alone, which keeps expanding at 8% every year (Adewumi et al., 2011). Delta State livestock industry is known to have poultry production as the predominant enterprise with layer production taking the central stage as it is a double-barreled approach serving both the egg and meat production purposes of poultry production. Generally, there is a tendency for farmers to focus on the main production output than the waste of any production system. However, since poultry fecal wastes generate a lot of environmental concerns and possess some economic value, there is a need to reconsider such waste viz-a-viz the economic impact on layer production.

1.2 Problem Statement

Nigerian poultry farmers faced with the need to intensify production have the problems of waste management and inflated input prices to grapple with. This is particularly true in terms of the long-term growth and sustainability of poultry production in larger bird facilities located near urban and peri-urban areas, as well as for smaller commercial systems associated with live bird markets, and for village and backyard flocks located in rural areas (Williams, 2013). It has been estimated that a layer bird produces about 63–70 kg of waste in a year and 1,000 layers can produce 1 tonne of manure weekly while in deep litters (Oluyemi and Roberts, 2000). There is far more quantity of waste than can be managed by land disposal being produced yearly (Gerber *et al*., 2008). While on the one hand, this shows the obvious problem of poultry waste management, on the other hand, it offers great opportunities for organic farming and bio-energy generation in Nigeria.

The sales of fecal waste from poultry farms increase revenue and ensure environmental stewardship at the same time as these wastes are recycled as organic manure for crop cultivation. Generating bioenergy from these wastes or developing other eco-innovative strategies to manage these wastes of environmental concern, is expected to reduce the cost of waste management and money spent on fossil fuel and electricity bills in the long run. Both approaches to managing waste ensure a cleaner environment and the generation of more revenue through the reduction of cost which is consistent with the objective function of profit maximization. In recent times, arable crop farmers from the northern part of Nigeria have besieged the South (Delta State inclusive) with a request for poultry droppings. This is obviously in recognition of its long-term benefit of helping to improve the soil's physical properties. However, since there is a dearth of information on the profitability of fecal waste or its contribution to the profitability or otherwise of layers enterprises in Delta State, this work is designed to answer the following research questions:

- What is the contribution of revenue from fecal waste to the profitability of layer farms in the study area?
- What is the profit efficiency of layer farms generating income from fecal wastes?

The broad objective of the study was to investigate the impact of fecal waste management on the profitability of poultry farmers in Nigeria and the specific objectives of this study were to:

- estimate the contribution of revenue from fecal waste to the profitability of layer farms in the study area.
- determine the profit efficiency of layer farms generating income from fecal wastes in the study area.

The above objectives were used to explain the hypothesis below:

- H_0: There is no significant contribution of fecal waste to the profitability of poultry farmers in the study area

1.3 Justification and Novelty

Numerous research efforts bordering on the economics and the profitability of poultry production in different parts of Nigeria exist. Adewunmi (2008) researched the economics of poultry production in Egba Division of Ogun State. Hassan *et al.*, (2016) did work on the economic analysis of poultry egg enterprise in Kaduna State, while Nmadu *et al.*, (2014) looked at the profitability and resource use efficiency of poultry egg production in Abuja. Emokaro and Erhabor (2014) did a comparative analysis of the profitability of layers production in Esan North East and Ovia North-East local government areas of Edo State. Joining this array of research, Achoja (2013) researched the allocative efficiency of feeds among poultry farmers in Delta State. Also, there have been several studies on the environmental effects of poultry production and the potential of poultry waste (Gerber *et al*, 2008; Williams, 2013; Alabi *et al*., 2014). It is also worth noting that outside Nigeria, there have been studies on the use and profitability of poultry manure in electricity generation. Works of Murphy *et al*., 2004; Gebrezgabher *et al.*, 2010 and Lassner, 2011 looked at various aspects of this eco-innovative way

of waste management. More specifically, bothered that the use of wastes for biogas production has been restricted to a few feedstocks like cattle manure and food waste, Ajieh *et al*., (2021), reasoned that increasing the feedstock base for biogas production can increase the sustainability of feedstock availability. Thus, the sociocultural and acceptability issues associated with the use of fecal waste as a source of energy in Benin City, Edo State, Nigeria were assessed. Ihoeghian *et al*., (2022), also looked at anaerobic co-digestion of cattle rumen content and food waste for biogas production as an alternative energy source. This was against the backdrop that Nigeria generates approximately 42 million tonnes of solid waste, with attendant poor waste management practices that have made it impossible to properly collect and harness these waste materials. However, while the plethora of research around profitability gives great insight to all stakeholders in the solid waste management and poultry subsector of the livestock industry, there is hardly any work on the economics of the fecal waste generated from poultry production in terms of their contribution to the profitability of the poultry enterprise and meeting the objective of environmental stewardship in line with the trend of eco-innovation. This identified gap is what this current research effort is designed to fill.

1.4 Review of Previous Studies

A major challenge in Nigeria in terms of poultry waste management is the fact that reliable data on the volume of waste generated from poultry farms annually are not readily available. In Nigeria, about 932.5 metric tonnes (MT) of manure are produced annually from the well-established poultry/livestock industries which keep expanding at 8% every year (Adewumi *et al*., 2011). It is obvious that with the increased intensification of poultry production over the past 15 years, the figures have soared. In Minna, North-Central Nigeria, Adeoye *et al*., (2014) reported an estimate of 100.97 tonnes of dead birds over a brooding cycle and about 159,430 metric tonnes of poultry manure being generated annually from the 117 poultry farms in that State. The case in the other States of the country may not be different. To better overcome the monumental task of poultry waste management, different waste management practices like sanitary landfills rendering faculties, extrusion machinery, compost plants, lagoons, or holding tanks and land application have been used (Pope, 1991).

Apart from being a by-product of poultry production, fecal waste has economic value and potential thus the potential for income in the farm. This is because they could be applied as manure for soil nutrient augmentation, thus saving or reducing the money that would have been spent on inorganic fertilizers for the case of poultry farms integrated with crop production. The value of the money saved through this process and from selling manure to crop farmers become an additional source of income from the poultry enterprise. Making money from fecal waste is also a way of waste management, thus this double-barreled model is what any farm can adopt. Researchers (Akanni and Benson, 2014; Alabi *et al*., 2014; Onu *et al*., 2014) have shown that one of the ways of managing poultry waste, especially fecal waste is through selling these wastes, especially for those involved in urban agriculture. In fact, in the research on poultry litter/manure management practices in intensively managed poultry farms in Port Harcourt (South-South Nigeria), it was shown that 53.3% of the respondents sell their bags of fecal waste immediately, 43.3% store and sell later, and 3.3% apply manure directly to their farmlands (Kalu, 2015). This shows that there is an available market, not just for poultry products but also for the by-products, specifically, fecal waste.

Beyond the sales of fecal waste for soil fertility supplementation, poultry and other types of animal wastes could be used as energy feedstock to generate biogas. The production of methane from biomass e.g., human excreta, animal manure, sewage sludge, and vegetable crop residues can be used in families, farms and industrial units for cooking, heating, and lighting, and in larger institutions for power generation (Simeon, 2009). Although this option has been adequately explored in many developed countries (Mehta, 2002; Murphy *et al*., 2004; Singh *et al.*, 2008; Gebrezgabher *et al*, 2010; Jensen *et al*., 2010; Lassner, 2011), there are only a few farms or institutions currently employing this technology of environmentally-friendly waste management in Nigeria. This may be due to ignorance, unavailability of technical know-how, unavailability of adequate poultry wastes to feed biogas digester to produce desired energy demand, lack of policy attention and government support, and lack of research on the feasibility and profitability amongst others.

However, whenever poultry farmers are ready to look toward methods to decrease farm energy costs, use energy for their operations in a sustainable manner, and sustainably dispose of litter, their interest would always increase in using poultry litter as a potential energy feedstock (Jensen *et al.*, 2010). The use of poultry wastes as energy feedstock for biogas generation is not only an efficient and environmentally friendly way of managing waste but also helps to save money or a part of the cost that would have been spent on electricity.

II. METHODS

2.1. Sampling and Sampling Procedure

The study was conducted in Delta State, Nigeria. The State lies approximately between Latitudes 5°00' and 6°30' North and Longitudes 5°00' and 6°45' East. It is bounded in the North by Edo State, the East by Anambra State, South-East by Bayelsa State, and on the Southern flank is the Bight of Benin (Delta State Ministry of Agriculture and Natural Resources, 2010). It is situated in the tropics and therefore experiences a fluctuating climate, ranging from the humid tropical in the South, and the sub-humid in the Northeast.

A three-stage sampling procedure was employed in drawing the sample. In the first stage, the stratification of the State into three zones following the ADP-Agricultural zones delineation namely, Delta North Agricultural Zone (DNAZ), Delta Central Agricultural Zone (DCAZ) and Delta South Agricultural Zone (DSAZ) was maintained. The second stage involved the simple random sampling of five blocks (LGAs) from DNAZ, five blocks from DCAZ and three blocks from the DSAZ. Since, poultry farms were randomly distributed in communities (cells) within these blocks, with some towns having several farms and others having no poultry farm at all, the third stage involved the use of a simple random sampling to select 12 poultry farms from each of the earlier selected blocks in DNAZ and DCAZ while eight poultry farms each were selected from the blocks of DSAZ. The ratio of farmers selected from the three zones was done in proportion to the total number of farms in the sampling frame. This selection was drawn from the sampling frame containing the lists of active layer farmers across the State as provided by the Delta State Ministry of Agriculture, Asaba and the Delta State Agricultural Development Programme, Ibusa. The sampling frame contained 224 active layer farmers and the sampling goal was to sample 130 layer farmers (58% of the sampling frame) satisfying the Central Limit Theorem and inclusion of a 10% buffer (i.e. 13 extra respondents) to give allowance for non-response and invalid responses. Thus 60 respondents each were obtained from DNAZ and DCAZ while 24 respondents came from DSAZ giving a total of 144 respondents in all. A total number of 144 copies of the research questionnaire were administered. However, upon collation, only 123 copies were found useful for further analysis, thus giving a response rate of 85.41%.

2.2. Analytical Techniques

Gross Margin Analysis: This was used to determine the profitability or otherwise of the poultry farmers. Gross Margin is the difference between gross income (revenue) and total variable cost (TVC) of production (Olukosi and Erhabor, 2005). This was one of the indices used in determining the costs, returns as well as the profitability of the poultry farmers in the study area. It was determined as follows:

$$GM = TR - TVC \tag{1}$$

Where;

GM = Gross Margin (₦),

TR = Total Revenue (₦),

TVC = Total Variable Cost (₦).

Net Farm Income**:** This was another index for profitability determination, and it represents the total profit and was determined using the:

$$NFI = TR - TC \tag{2}$$

Where;

NR = Net Farm Income; TR = Total Revenue and TC= Total Cost.

$$TR = P_V V + P_W W + P_X X + P_Y Y + P_Z Z \tag{3}$$

But:

$$TC = TVC + TFC = TVC + Depreciation\ on\ Fixed\ Input \tag{4}$$

P_v = Price of eggs; v = quantity of eggs (in crates); P_w = Price of cracked eggs; w = quantity of cracked eggs (in crates); P_x = Price of spent bird x = quantity of spent birds (in kg); P_y = Price of fecal waste; y = quantity of fecal waste (in bags of kg); P_z = Price of feed bags/sack; z = quantity of feed bags/sack (in dozens).

Profitability Index (PI) = $\frac{NFI}{GM}$ (5)

Rate of Return to Investment (RRI) = $\frac{NFI}{TC} * 100$ (6)

Return Per Naira Invested on Variable Cost = $\frac{GM}{TVC}$ (7)

The depreciation of all fixed assets (cost) was calculated using the Straight-Line Method as shown below:

$$D = C - \frac{S}{N} \tag{8}$$

Where;

D = Depreciated amount; C = Initial cost of the assets; S = Scrap value (which in this case is assumed to be zero); and N = Expected number of useful life spans.

Furthermore, the Student's t-test was used to find out if there is a significant contribution of fecal waste to the profitability measures of poultry farmers. The formula for the T-test is given below:

$$t = (X_1 - X_2)/S_d \tag{9}$$

Where;

$$S_d = \frac{\sqrt{S_1^2}}{n_1} + \frac{\sqrt{S_2^2}}{n_2} \tag{10}$$

Where;

X_1 = Mean of the first set of values (those who make money from fecal waste), X_2 = Mean of the second set of values (those who do not make money from fecal waste), s_1 = Standard deviation of the first set of values, s_2 = Standard deviation of the second set of values, n_1 = Total number of values in the first set, n_2 = Total number of values in the second set.

While the formula for standard deviation is given:

$$S = \sqrt{\sum (x-\mu)^2 /(n-1)} \tag{11}$$

Where;

x = profit of a given layer farmer, μ = Mean profit of layer farmers, n = Total number of layer farmers.

The profit function was used to determine the profit efficiencies of farms generating income from fecal wastes in the study area by employing the stochastic profit frontier model. This followed Battese and Coelli (1995) who extended the stochastic production frontier model by suggesting that inefficiency effects can be expressed as a linear function of explanatory variables, reflecting farm-specific characteristics. The advantage of the model is that it makes it possible to estimate the specific efficiency scores and the factors explaining the efficiency differentials among farmers in a single-stage estimation procedure.

The profit function which is assumed to behave in a manner consistent with the stochastic frontier concept is defined as:

$$\pi_i = f(P_{ij}, Z_{ik}).\exp(\varepsilon_i) \tag{12}$$

Where;

π_i is the normalized profit of the i^{th} farm defined as gross revenue less variable cost, divided by farm-specific output price P; P_{ij} is a vector of j^{th} variable input prices faced by the i^{th} farm divided by output price (in this case, the price of fecal waste); Z_{ik} is the level of the *kth* of fixed factors on the i^{th} farm; ε_i is an error term; here i =1,., n, is the number of poultry farms in the sample. The assumption here is that the error term ε_i behave in a manner consistent with the frontier concept, that is;

$$\varepsilon_i = v_i - \mu_i \tag{13}$$

The symmetric two-sided error term (v) accounts for random variation in profit attributed to factors outside the farmer's control (white noise). The one-sided component (μ) is a non-negative error term accounting for the inefficiency of the farm. Therefore, it represents the profit shortfall from its maximum possible value on the stochastic profit frontier.

A multiple regression model based on the stochastic frontier profit function which assumes a translog functional form was employed to determine the profit efficiency of farmers generating revenue from wastes in the study area. This is in line with Ifeanyi and Onyenweaku (2007). It was chosen due to its inherent advantage as well as suitability in estimating sole enterprises and analyzing interactions among input variables and the output. This is specified below:

$$\ln\pi^*_i = a_0 + a_1\ln X_1 + a_2\ln X_2 + a_3\ln X_3 + a_4\ln X_4 + a_5\ln X_5 + a_6\ln X_6 + a_7\ln X_7 + 0.5a_{11}\ln(X_1)^2 + 0.5a_{22}\ln(X_2)^2 + 0.5a_{33}\ln(X_3)^2 + 0.5a_{44}\ln(X_4)^2 + 0.5a_{55}\ln(X_5)^2 + 0.5a_{66}\ln(X_6)^2 + 0.5a_{77}\ln(X_7)^2 + a_{12}\ln X_1{*}\ln X_2 + a_{13}\ln X_1{*}\ln X_3 + a_{14}\ln X_1{*}\ln X_4 + a_{15}\ln X_1{*}\ln X_5 + a_{16}\ln X_1{*}\ln X_6 + a_{17}\ln X_1{*}\ln X_7 + a_{23}\ln X_2{*}\ln X_3 + a_{24}\ln X_2{*}\ln X_4 + a_{25}\ln X_2{*}\ln X_5 + a_{26}\ln X_2{*}\ln X_6 + a_{27}\ln X_2{*}\ln X_7 + a_{34}\ln X_3{*}\ln X_4 + a_{35}\ln X_3{*}\ln X_5 + a_{36}\ln X_3{*}\ln X_6 + a_{37}\ln X_3{*}\ln X_7 + a_{45}\ln X_4{*}\ln X_5 + a_{46}\ln X_4{*}\ln X_6 + a_{47}\ln X_4{*}\ln X_7 + a_{56}\ln X_5{*}\ln X_6 + a_{57}\ln X_5{*}\ln X_7 + a_{67}\ln X_6{*}\ln X_7\, v_i - \mu_i \tag{14}$$

Where:

π^*_i = restricted profit (total revenue less total cost of variable inputs) profit normalized by the price of the output computed for the i^{th} farmer; ln = natural log; X_1 = normalized cost of layer feed (in Naira); X_2 = normalized cost of labor (in Naira); X_3 = cost of stock/birds (in Naira); X_4 = normalized veterinary cost (in naira); X_5 = normalized cost of labor for fecal waste management (in Naira); X_6 = normalized cost of bags for waste; X_7 = depreciation on fixed assets; a_0 and a_{1-7} are parameters to be estimated, v_i represents statistical disturbance term and μ_i = represents profit inefficiency effects of i^{th} poultry farmer generating income from fecal waste.

The determinants of profit inefficiency of layer/egg production in line with Bamiro *et al.* (2013) were modeled following specific characteristics of farmers in the study area. From equation (13) component is specified as follows:

$$\mu_i = l_0 + \sum_{d=1}^{5} l_d W_d + k \qquad (15)$$

Where:

μ_i = Profit inefficiency of i^{th} farmer; l_0 and l_d are parameters to be estimated; W_d = variables representing socioeconomic variables (d =1,2,3...., n,); W_1 = ages (in years); W_2 = education (yearsj); W_3 = years farming experience; W_4 = Household size (head count); W_5 = Cooperative membership (Member = 0, Nonmember =1); k is truncated random variable.

III. RESULTS AND DISCUSSION

3.1. Socioeconomics Characteristics of Poultry Farmers in the Study area

Results presented in Table 1 show that the majority (66.67%, 73.47%, 65% and 69.11%) of the poultry farmers in Delta North Agricultural Zone (DNAZ), Delta Central Agricultural Zone (DCAZ), Delta South Agricultural Zone (DSAZ) and pooled sample respectively were males, indicating that only a few females were actively involved. Thus, the industry is male-dominated. Age distribution among the majority (85.19%, 83.67%, 90% and 85.17%) of the poultry farmers in DNAZ, DCAZ, DSAZ and pooled sample were within 25-54 years, 55-64 years, 25-54 years, and 25-54 years of age, respectively. The mean ages were 46 years, 45 years, 45 years, and 46 years, respectively. This implies that the majority of the farmers were young, agile and within their active age, this may positively influence their productivity. This finding resonates with the findings of Yusuf and Malomo (2007) who reported an average age of 44 years.

The greater proportion (57.41%, 69.39%, 65% and 63.41%) of the farmers in DNAZ, DCAZ, DSAZ and pooled sample had tertiary education. This implies that the majority of them were well-educated. Generally, educated farmers are more receptive and apt to adopt new technologies that would enhance productivity, better manage waste, and increase profit, and profit efficiency (Paltasingh and Goyari, 2018). The greater proportion (46.3%, 46.94%, 55% and 47.97%) of the respondents in DNAZ, DCAZ, DSAZ and pooled sample respectively had 6 -10 years of poultry farming experience. The mean farming experience for DNAZ, DCAZ, DSAZ and the pooled sample was seven years, six years, eight years, and seven years, respectively. Since the continuous practice of an occupation for a long time has the potential of making a person more experienced and productive in the practice, it could imply that they have good experience in poultry production, a development that can influence their efficiency and productivity positively. Concerning household size, a greater proportion (61.11%, 61.22%, 55% and 60.16%) of the farmers in DNAZ, DCAZ, DSAZ and pooled sample had a household size of 4 - 6 persons. The mean household size was five persons. This implies that the majority of the farmers had a fairly large size of household members, thus increasing their employment of family labor.

Table 1: Frequency and Percentage Distribution of Farmers according to their Socio-economic Characteristics

Variable	**Description**	**DNAZ**		**DCAZ**		**DSAZ**		**Pooled**	
		Freq.	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Sex	Male	36	66.67	36	73.47	13	65.00	85	69.11
	Female	18	33.33	13	26.53	7	35.00	38	30.89
Age (years)	≤30			1	2.04			1	0.81
	31-40	16	29.63	18	36.74	5	25.00	37	30.08
	41-50	22	40.74	14	28.57	11	55.00	49	39.84
	51-60	12	22.22	13	26.53	4	20.00	29	23.58
	Above 60	4	7.41	3	6.12			7	5.69
	Mean	46		45		45		46	
	Standard deviation	8.48		9.06		6.32		8.36	

Level of education	Primary	3	5.56	2	4.08			5	4.07
	Secondary	20	37.04	13	26.53	7	35.00	40	32.52
	Tertiary	31	57.41	34	69.39	13	65.00	78	63.41
Farming experience (years)	1-5	20	37.04	26	53.06	4	20.00	50	40.65
	6-10	25	46.30	23	46.94	11	55.00	59	47.97
	11-15	8	14.81			5	25.00	13	10.57
	16-20	1	1.85					1	0.81
	Mean	7		6		8		7	
	Standard deviation	3.33		2.10		3.15		2.97	
Household size (persons)	1-3	10	18.52	12	24.49	3	15.00	25	20.33
	4-6	33	61.11	30	61.22	11	55.00	74	60.16
	7-9	11	20.37	7	14.29	6	30.00	24	19.51
	Mean	5		5		5		5	
	Standard deviation	1.64		1.95		1.56		1.78	

3.2. Profitability of Poultry Production

The mean result of the profitability accruable from poultry farming is presented in Table 2. The result showed that the average revenue realized by the farmers in the study area was ₦30,773,161.91. Revenue from egg production was ₦27,489,426.19, the revenue realized from cracked eggs was ₦287,336.37, and revenue realized from culled layers was ₦2,923,621.89 while revenue realized from fecal waste was ₦72,777.45. The total cost of production incurred by the farmers was ₦25,806,399.9, and the variable cost incurred was ₦25,001,724.81 which represented most (96.88%) of the total production cost. The cost of feed contributed 88.51% to the total production cost. The fixed cost of production was ₦804,675.15 and this contributed 3.12% to the total cost of production. The gross margin and net farm income were ₦5,771,437.10 and ₦4,966,761.94, respectively. The positive gross margin and net farm income imply that this is a profitable enterprise in the area. The profitability measures (Profitability Index, Rate of Return on investment and Return on Variable Cost) showed that poultry production in the area is profitable. The Profitability Index showed that for every naira earned as revenue, ₦0.86 returned to the producers as net income. In other words, 86% of the total revenue earned constituted the net income. This implies that an appreciable profit level can be made from the enterprise. The rate of return on investment (RRI) in this study was estimated to be 19.25%, implying that for every one naira spent or invested in layer production by farmers in the study area, the farmers earned on average 19.25% profit.

Table 2: Mean Cost and Return Structure of Layer Production

Variable	Quantity	Cost/unit	Value (₦)	% Total Cost
Revenue				
Eggs produced/season	30,216.26	909.76	27,489,426.19	
Cracked eggs sold/season	803.24	357.72	287,336.37	
Layers disposed	2,336.62	1,251.22	2,923,621.89	
Fecal waste per season	209.93	346.67	72,777.45	

Total Revenue			**30,773,161.91**	
Variable Cost				
Labor cost	82	10,645.19	873,944.21	3.39
Cost of feed	7,922.26	2,883.05	22,840,257.25	88.51
Electricity cost	38.02	3,769.51	143,327.09	0.56
Fuel	37.11	9,397.45	348,781.73	1.35
Stock/DOC	2,533.83	178.83	453,115.52	1.76
Veterinary cost	2,533.83	130.70	331,159.16	1.28
Labor for waste management			11,139.85	0.04
Total variable cost			**25,001,724.81**	**96.88**
Fixed cost				
Depreciation on Fixed inputs			636,770.51	2.47
Feeding bag	660.63	247.24	163,332.16	0.63
Cost of waste sacks			4,572.48	0.02
Total fixed cost			804,675.15	3.12
Total cost			**25,806,399.96**	**100.00**
GM			5,771,437.10	
NFI			4,966,761.94	
PI			0.86	
RRI			19.25	
Return on Variable Cost			0.23	

3.3. Contribution of Fecal Waste to Profitability

The result for testing the hypothesis of whether fecal waste contributes significantly to profitability or not is shown in Table 3. The null hypothesis was tested using a paired student t-test. The result of the hypothesis test showed that the probability of the test statistics of the profitability measures (0.314, 0.157 and 0.843) was higher than the critical probability value of 0.05, leading to a non-rejection of the null hypothesis. This result implies that fecal waste generation has no significant contribution to the profitability index and rate of return on investment of the farmers. This might be because the amount of revenue generated from layer waste is small compared to that generated from eggs, cracked eggs, and culled layers.

Table 3: Result of Test of Hypothesis

Null hypothesis	Profitability measures	Fecal	Non-fecal	Mean difference	p-value	decision
There is no significant contribution of fecal waste to profitability	PI	0.86	0.86	0.00	0.314	Fail to reject null
	RRI	19.25	18.96	0.29	0.157	Fail to reject null

3.4. Profit Efficiency of Layer Farmers

The result of the Maximum Likelihood Estimates (MLE) of the parameters of the Translog profit efficiency and inefficiency model of the layer farmers is presented in Tables 4 and 5, respectively. The variance parameters, sigma-square and gamma were estimated at 0.142 ($p< 0.01$) and 0.928 ($p<0.01$), respectively. The sigma-square attests to the goodness of fit and correctness of the distributional form assumed for the composite error term while the gamma indicates the systematic influences that are unexplained by the profit function and the dominant sources of random errors. This implies that about 92.8% of the variation in profit is due to the differences in their inefficiency. The parameter estimates of the translog functional form of the stochastic frontier suggest that cost of feed ($p<0.01$), cost of bird/stock ($p<0.05$) and depreciation on fixed assets ($p<0.01$) negatively influenced the profit of the farmers while veterinary cost ($p<0.01$) and labor cost for fecal waste management ($p<0.01$) had a positive influence on profit of layer farmers.

The coefficient of feed showed that a 1% increase in the cost of feed would reduce the profit by 18.25%. This is so because feed is a vital input in poultry production and about 70-80% of the production cost was expended on feed, any attempt to raise the cost of feed will result in to decrease in the profit of the farmers. The coefficient of stock showed that a 1% increase in the cost of birds would reduce the profit by 9.44%. Increasing the cost of layer birds will reduce the profit of the farmers. The coefficient of veterinary cost showed that a 1% increase in the cost of veterinary services would increase the profit by 8%. This is so because as veterinary cost increases so do the layer birds become healthier thereby resulting in higher output which will invariably increase the profit level of the farmers. The coefficient of cost of labor for fecal waste management showed that a 1% increase in the cost of fecal waste management would increase the profit of the farmers by 1.17%. The coefficient of depreciation on fixed assets showed that a 1% increase in the cost of depreciation of fixed assets would reduce the profit by 9.36%. This is so because fixed assets like cages, pens, and buildings are vital in poultry production and any attempt to increase their cost will have a negative impact on the profit level of the farmers.

Table 4: Maximum Likelihood Estimates of Profit Efficiency Model

Variable	Coefficient	Standard Error	z-value	P-value
Feed	-18.251***	4.516	-4.040	0.000
Stock	-9.435**	4.402	-2.140	0.032
Labor	3.307	3.295	1.000	0.316
Veterinary	8.002***	2.582	3.100	0.002
Labor*Waste	1.174***	0.372	3.150	0.002
Bag*Waste	-0.571	1.791	-0.320	0.750
Depreciation on Fixed Assets	-9.362***	1.456	-6.430	0.000
Feed*Feed	-1.953***	0.128	-15.280	0.000
Stock*Stock	-1.800	5.563	-0.320	0.746
Labor*Labor	-0.210	0.614	-0.340	0.732
Veterinary*Veterinary	0.987	0.700	1.410	0.159
$(\text{Labor*Waste})^2$	-0.202	0.168	-1.200	0.231
$(\text{Bag*Waste})^2$	0.058	0.198	0.290	0.771
$(\text{Depreciation on Fixed Assets})^2$	-1.802*	0.992	-1.820	0.069
Feed*Stock	6.892***	1.731	3.980	0.000
Feed*Labor	-1.316	1.339	-0.980	0.326
Feed*Veterinary	5.545	.	.	.
Feed*Labor*Waste	0.072	0.767	0.090	0.925
Feed*Bag*Waste	0.483	1.067	0.450	0.651
Feed*Depreciation on Fixed Assets	13.536***	1.069	12.660	0.000

Stock*Labor	-0.116	1.009	-0.110	0.909
Stock*Veterinary	-13.123***	1.954	-6.720	0.000
Stock*Labor*Waste	-1.076	1.318	-0.820	0.414
Stock*Bag*Waste	0.001	0.001	0.790	0.428
Stock*Depreciation on Fixed Assets	-13.491	.	.	.
Labor*Veterinary	2.144	1.749	1.230	0.220
$Labor^2$*waste	0.433**	0.218	1.990	0.046
Labor*Bag*Waste	-0.482	0.501	-0.960	0.335
Labor*Depreciation on Fixed Assets	-0.836	0.522	-1.600	0.109
Veterinary*Labor*Waste	0.055	0.574	0.100	0.923
Veterinary*Bag*Waste	-0.095	1.159	-0.080	0.934
Veterinary* Dep. on Fixed Assets	2.155***	0.803	2.680	0.007
Labor*Waste*Bag*Waste	0.011	0.101	0.110	0.910
Labor*Waste*Dep. On Fixed Asset	0.434	0.306	1.420	0.156
$Sigma^2$	0.142	0.018		
Gamma	0.928	0.024		
Log likelihood	30.816			

****, ** and * means significant at 1%, 5% and 10% respectively.*

3.5. Determinants of Profit Inefficiency of Poultry Farmers

The result of the determinants of profit inefficiency is presented in Table 5. The result showed that age ($p<0.1$) and cooperative membership ($p<0.01$) positively influence profit inefficiency while education ($p<0.01$) and household size ($p<0.05$) negatively influence profit inefficiency. The coefficient of age revealed that an increase in age increases profit inefficiency. This implies that older farmers are more profit inefficient compared to their younger counterparts. This may be because as age increases so does the ability to be more productive reduces thereby making farmers less profit efficient. The coefficient of education showed that as the number of years spent in school increases the profit inefficiency of the farmers reduces. This is so because education exposes the farmers to innovative ways of raising their birds at reduced cost thereby reducing their profit inefficiency. The coefficient of household size showed that an increase in the size of the household reduces the profit inefficiency of the farmers. This might be because most of the layer farmers engaged their household members on their farms to save costs expended on labor, this will invariably increase their profit level. The coefficient of cooperative membership suggests that the profit inefficiency of the farmers that are members of cooperative society increases than their counterparts that are non-members of cooperative society. This might be because those that belonged to cooperative societies did not receive adequate training and financial support from their association.

Table 5: Estimates of Determinants of Profit Inefficiency

Variable	**Coefficient**	**Standard Error**	**z-value**	**P-value**
Constant	0.377***	0.104	3.630	0.000
Age	0.003*	0.002	1.680	0.096
Education	-0.088***	0.022	-3.910	0.000
Farming experience	-0.005	0.005	-1.050	0.294
Household size	-0.019**	0.008	-2.450	0.016
Cooperative membership	0.149***	0.035	4.210	0.000

IV. CONCLUSION AND RECOMMENDATION

From the analysis, poultry production is profitable with a high potential for farmers to make more profit than the current average farmers if inputs are more efficiently used. The following recommendations are suggested:

- Farmers are advised to invest in their education as this is shown to have a significant negative effect on their profit inefficiency.
- Poultry farmers are advised to creatively manage the factors of production that significantly affect their profitability such as veterinary costs, cost of birds, cost of labor for fecal waste management and depreciation to improve the performance of their farm.

If these recommendations are adequately followed, there will be a boost to poultry production in the study area as well as an increase in the income of layer farmers. In addition, a sub-enterprise will be created from fecal waste which has great untapped potential, while production goes on in an environmentally sustainable manner.

REFERENCES

[1] Achoja F. O. (2013). Allocative efficiency of feeds among poultry farmers in Delta state, Nigeria. *Russian Journal of Agricultural and Socio-Economic Sciences*, 14(2), 26-33.

[2] Adeoye, P. A., Hasfalina, C. M., Amin, M. S. M., Thamer, A. M., and Akinbile, C. O. (2014). Environmental implication of poultry waste generation and management techniques in Minna, semi-arid region of Nigeria. *Annual Research & Review in Biology*, 1669-1681.

[3] Adewumi, A. A., Adewumi, I. K., and Olaleye, V. F. (2011). Livestock waste-menace: Fish wealth-solution. *African Journal of Environmental Science and Technology*, 5(3), 149-154.

[4] Adewunmi, O. I. (2008). Economics of poultry production in Egba division of Ogun State. *Medwell Online Agricultural Journal*, 3(1), 9-12.

[5] Ajieh, M.U., Isagba, E.S., Ihoeghian, N., Edosa, V.I.O., Amenaghawon, A., Oshoma, C.E., Erhunmwunse, N., Obuekwe, I. S., Tongo, I., Emokaro, C.O., and Ezemonye, L.I.N. (2021). Assessment of socio-cultural acceptability of biogas from faecal waste as an alternative energy source in Benin City, Edo State, Nigeria. *Environ Dev Sustain* 23, 13182–13199 (2021). https://doi.org/10.1007/s10668-020-01205-y

[6] Akanni, K. A., and Benson, O. (2014). Poultry wastes management strategies and environmental implications on human health in Ogun state of Nigeria. *Adv. Econ. Bus*, 2, 164-171.

[7] Alabi, R. A., Aghimien, C. I., Osasogie, D. I., and Otasowie, G. E. (2014). Environmental Effects of Poultry Production in Edo State, Nigeria. *American Journal of Experimental Agriculture*, 4(12), 1773.

[8] Bamiro, O. M., Otunaiya, A. O., & Adejumo, I. (2013). Profit efficiency in poultry production in Peri-Urban Lagos, Nigeria. *International Journal of Applied Agriculture and Apiculture Research*, 9(1-2), 120-130.

[9] Battese, G. E., & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical economics*, 20(2), 325-332.

[10] CSIRO, (2021). Poultry production in Nigeria. Available at: https://research.csiro.au/livegaps/findings/livestock-production/poultry-production-in-nigeria/ [Assessed October 18, 2022]

[11] Delta State Ministry of Agriculture and Natural resources (MANR) (2010) Official bulletin.

[12] Emokaro, C. O., and Erhabor, P. O. (2014). Comparative Analysis of Profitability of Layers Production in Esan North East and Ovia North East Local Government Areas of Edo State, Nigeria. *Journal of Applied Sciences and Environmental Management*, 18(1), 121-126.

[13] Farrell, D. (2013). The role of poultry in human nutrition. Poultry Development Review. Rome: Food and Agriculture Organization, pp.2-9.

[14] Gebrezgabher, S. A., Meuwissen, M. P., Prins, B. A., and Lansink, A. G. O. (2010). Economic analysis of anaerobic digestion—A case of Green power biogas plant in The Netherlands. *NJAS: Wageningen Journal of Life Sciences*, 57(2), 109-115.

[15] Gerber, P., Opio, C., and Steinfeld H. (2008). Poultry production and the environment – A review. Rome, Italy: Food and Agriculture Organization of the United Nations.

[16] Hassan, A. A., Ahmadu, H. J., Oseni, Y., Dawang, N. C., Rahman, S. A., and AbdulSalam, Z. (2016). Economic Analysis of Poultry Egg Enterprise in Kaduna State, Nigeria.

[17] Heise, H., Crisan, A., and Theuvsen, L. (2015). The poultry market in Nigeria: Market structures and potential for investment in the market. *International Food and Agribusiness Management Review*, 18(1030-2016-83098), 197-222.

[18] Ihoeghian, N.A., Amenaghawon, A.N., Ajieh, M.U., Oshoma, C.E., Ogofure, A., Erhunmwunse, N. O., Edosa, V.I.O., Tongo, I., Obuekwe, I.S., Isagba, E.S., Emokaro, C.O., Ezemonye, L.I.N., Lag-Brotons, A.J., Semple, K.T., Martin, A.D., (2022). Anaerobic co-digestion of cattle rumen content and food waste for biogas production: establishment of co-digestion ratios and kinetic studies. Bioresource Technology Reports 18 (2022) 101033. www.sciencedirect.com/journal/bioresource-technology-reports

[19] Itodo, I. N., Awulu, J. O., and Philip, T. (2001). A comparative analysis of biogas yield from poultry, cattle and piggery wastes. In Livestock Environment VI, Proceedings of the 6th International Symposium 2001 (p. 402). *American Society of Agricultural and Biological Engineers.*

[20] Jensen, K. L., Roberts, R. K., Bazen, E., Menard, R. J., and English, B. C. (2010). Farmer willingness to supply poultry litter for energy conversion and to invest in an energy conversion cooperative. *Journal of Agricultural and Applied Economics*, 42(1), 105-119.

[21] Kalu, E. (2015). Poultry litter/manure management practices in intensively managed poultry farms in portharcourt. *IOSR J. Agric. Vet. Sci*, 8(3), 53-58.

[22] Lassner, K. (2011). Financial and Economic Analyses of Biogas-to-Energy Projects in Brazil.

[23] Mehta, A. (2002). The economics and feasibility of electricity generation using manure digesters on small and mid-size dairy farms. Available at SSRN 2638078.

[24] Miebi, G.T. (2020). Contributing Factors of the Choice of Poultry Waste Management Practices: Evidence from Nigeria. *International Journal of Environment, Agriculture and Biotechnology*, 5(3).

[25] Murphy, J. D., McKeogh, E., and Kiely, G. (2004). Technical/economic/environmental analysis of biogas utilisation. *Applied Energy*, 77(4), 407-427.

[26] Nmadu, J. N., Ogidan, I. O., and Omolehin, R. A. (2014). Profitability and resource use efficiency of poultry egg production in Abuja, Nigeria. *Kasetsart Journal of Social Sciences*, 35(1), 134-146.

[27] Nwachukwu, I. N., & Onyenweaku, C. (2007). Economic efficiency of Fadama Telfairia production in Imo State Nigeria: A translog profit function approach.

[28] Odemero, A. F. (2013). Allocative efficiency of feeds among poultry farmers in Delta state, Nigeria. Russian Journal of Agricultural and Socio-Economic Sciences, 14(2), 26-33.

[29] Olukosi, J. O. and Erhabor, P. O. (2005). Introduction to farm management economics, principles and application, Agitab publishers Limited, Zaria p.23.

[30] Oluyemi, J. A., and Roberts, F. A. (2000). Poultry production in warm wet climates. Ibadan. *Spectrum Book Limited*, 2(2), 57-62.

[31] Onu, D. O., Offor, E. I., & Okpara, B. O. (2015). Poultry wastes management strategies and environmental implications in Abia State. *International Research Journal of Agricultural Science and Soil Science.*

[32] Paltasingh, K. R., & Goyari, P. (2018). Impact of farmer education on farm productivity under varying technologies: case of paddy growers in India. *Agricultural and Food Economics*, 6(1), 1-19.

[33] Pope, C. W. (1991). Poultry production's environmental impact on water quality. *Poultry Science*, 70(5), 1123-1125.

[34] Qaid, M. M. and Al-Garadi, M. A. (2021). Protein and amino acid metabolism in poultry during and after heat stress: A review. Animals, 11(4), p.1167.

[35] Simeon, T. O. (2009). Techno-economic analysis of a model biogas plant for agricultural applications: A case study of the Concordia Farms Limited, Nonwa, Tai, Rivers State. Published M. Eng. Project work of the Department of Mechanical Engineering University of Nigeria, Nsukka. Retrieved on April, 25, 2017 from http://www.unn.edu.ng/publications/files/images/M.ENG__0.pdf.

[36] Singh, R., Karki, A. B., and Shrestha, J. N. (2008). Production of biogas from poultry waste. *Journal of Renewable Energy and Smart Grid Technology*, 3(1), 11-20.

[37] Williams, C. M. (2013). Poultry waste management in developing countries. the role of poultry in human nutrition, 46.

[38] Yusuf, S. A., and Malomo, O. (2007). Technical efficiency of poultry egg production in Ogun state: a data envelopment analysis (DEA) approach. *International journal of poultry science*, 6(9), 622-629.